

PCTWORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :

H01L 33/00, 25/075, F21K 7/00 // F21W
121:00

A1

(11) International Publication Number:

WO 00/63977

(43) International Publication Date:

26 October 2000 (26.10.00)

(21) International Application Number:

PCT/EP00/03074

(22) International Filing Date:

6 April 2000 (06.04.00)

(30) Priority Data:

99201247.6

20 April 1999 (20.04.99)

EP

(71) Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V.
[NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven
(NL).(72) Inventor: HARBERS, Gerard; Prof. Holstlaan 6, NL-5656
AA Eindhoven (NL).(74) Agent: MULDER, Cornelis, A., M.; Internationaal Octrooibu-
reau B.V., Prof Holstlaan 6, NL-5656 AA Eindhoven (NL).(81) Designated States: CN, JP, KR, European patent (AT, BE, CH,
CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL,
PT, SE).

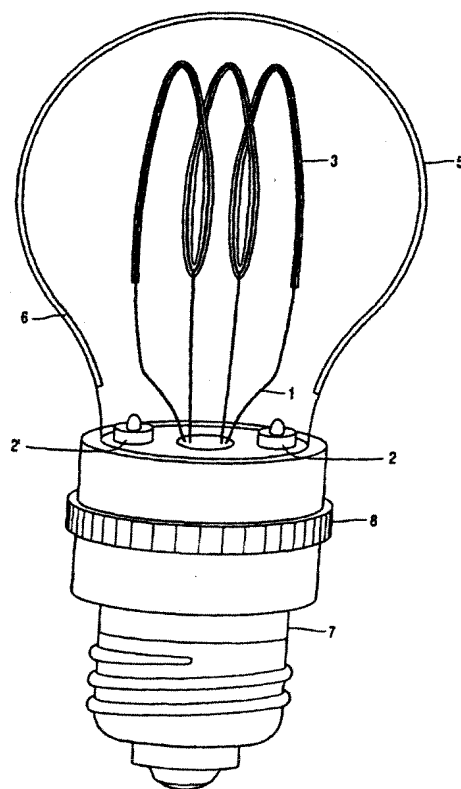
Published

With international search report.

(54) Title: LIGHTING SYSTEM

(57) Abstract

The lighting system comprises a body (1) to emit visible light and an envelope (5) which is transparent to light. The invention is characterized in that the lighting system comprises at least one opto-electronic element (2, 2') to emit light in a first wavelength range, in that the body (1) is provided with conversion means (3) for absorbing light emitted by the opto-electronic element (2, 2') and re-emitting light in a second wavelength range, and in that the envelope (5) is provided with a coating (6) reflecting light of the first wavelength range. In a preferred embodiment, the opto-electronic elements (2, 2') are light-emitting diodes, which preferably emit blue light. Preferably, the conversion means (3) consist of a luminescent material and can be excited, preferably, by light originating from the wavelength range of 400 to 500 nm. Preferably, the coating (6) comprises a multilayer optical filter and is, preferably, provided on an inside surface of the envelope (5). In operation, the luminous flux of the opto-electronic element is preferably equal to or higher than 5 lm. The body (1) may assume various shapes, such as a spiral-shaped coil, so that the lighting system resembles a carbon filament lamp. The lighting system according to the invention has a comparatively high luminous efficacy and a relatively long service life.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Lighting system

The invention relates to a lighting system comprising a body which, in operation, emits visible light and comprising an envelope which transmits light.

Lighting systems of the type mentioned in the opening paragraph are known per se and comprise, for example, incandescent lamps, such as decorative lamps, for example so-called carbon filament lamps, wherein the incandescent body comprises a spirally wound wire of carbon on a carrier material. Other examples of such lighting systems include lamps provided with a light-emitting body in the form of cross-shaped, star-shaped elements or other decorative or devotional elements (for example the letters "love").

It is a drawback of such lighting systems that the known lighting system has a relatively low luminous efficacy and a limited service life.

It is an object of the invention to provide a lighting system of the type mentioned in the opening paragraph, wherein the luminous efficacy and the service life are improved. To achieve this, the lighting system in accordance with the invention is characterized in that

the lighting system comprises at least one opto-electronic element which, in operation, emits light in a first wavelength range,

in that the body is provided with conversion means for converting light of the first wavelength range to light of a second wavelength range, and

in that the envelope is provided with a coating which at least partly reflects light of the first wavelength range.

Opto-electronic elements include electro-luminescent elements, such as light-emitting diodes (LEDs). Such opto-electronic elements are used as a source of white or colored light for general lighting purposes and as a source of colored or white light in signal lamps, for example in traffic control systems, vehicles, aircraft or other means or systems of transport. In recent years, apart from yellow and red light emitting diodes on the basis of GaP, efficient blue and green light emitting diodes on the basis of GaN have been developed. Such opto-electronic elements have a relatively high luminous efficacy (≥ 20 lm/W) and a relatively long service life ($\geq 75,000$ hours). By way of comparison, a 75 W carbon filament lamp has a

luminous efficacy of approximately 2 lm/W and an average service life of less than 1,000 hours.

In operation, in the known lamp light is generated in that the (incandescent) body in a (vacuumtight) envelope is heated by means of an electric current, causing said body to emit light at a high temperature. In the known lamp, the (incandescent) body constitutes the so-called primary light source. In accordance with the invention, the (incandescent) body of the known lighting system has been replaced by a combination of at least an opto-electronic element and (a body provided with) conversion means which convert light, which is emitted by the opto-electronic element in a first wavelength range, to light in a second wavelength range. In the lighting system in accordance with the invention, the opto-electronic element is considered to be a primary light source, and the conversion means are considered to be a secondary light source. The conversion means are excited by light originating from the opto-electronic element. A part of this light is converted by the conversion means, for example via a process of absorption and emission, to (visible) light in the second wavelength range.

In accordance with the invention, the light-transmitting envelope further comprises a coating which at least partly reflects light of the first wavelength range. As a result, it is achieved that light of the first wavelength range, which originates from the opto-electronic element and which is not directly absorbed by the conversion means and converted to light in the second wavelength range, is reflected by the reflective coating applied to (an inner surface of) the envelope and still absorbed by the conversion means and converted to light in the second wavelength range. Light originating from the conversion means is allowed to pass by the envelope coated with the reflective layer. The reflective coating causes the body which, in principle, is irradiated only from below to be a homogeneously radiating body.

In accordance with the measure of the invention, a high-efficacy lighting system having a relatively long service life is obtained. In the lighting system in accordance with the invention, the envelope no longer serves as a vacuum envelope but as a means for providing the reflective coating. As a result of the fact that the lamp in accordance with the invention no longer has a vacuum envelope, said lamp in accordance with the invention is also safer to use. The envelope provided with the reflective coating may also be omitted, if so desired. The lighting system then comprises a combination of at least an opto-electronic element and (a body provided with) conversion means.

Preferably, the conversion means comprise a luminescent material. Such materials are particularly suitable because they generally have a high quantum efficiency and a high lumen equivalent (expressed in lm/W), so that a high luminous efficacy of the lighting

system is achieved. In addition, a great variety of (stable) inorganic and organic luminescent materials (phosphors) is known, which makes it easier to choose a suitable material for achieving the object of the invention (improving the color rendition).

5 The luminescent material can preferably be excited by light originating from the wavelength range of 400 to 500 nm. As a result of this sensitivity, the luminescent material can particularly suitably be used to absorb, in particular, blue light. This absorbed light is very efficiently converted by the luminescent material to visible light in the further wavelength range, for example green or red light. The desired color temperature of the lighting system depends on the application. For a lighting system in the form of a look-alike of a carbon
10 filament lamp, a relatively low color temperature is desired. For other applications, light having a high color temperature may be obtained.

A particularly attractive embodiment of the lighting system in accordance with the invention is characterized in that the at least one opto-electronic element comprises a blue light-emitting diode, and that the conversion means comprise a luminescent material for
15 converting a part of the light emitted by the blue light-emitting diode to red light.

Preferably, the maximum of the spectral emission of the blue light-emitting diode lies in the wavelength range from 460 to 490 nm, and the maximum of the spectral emission of the red light-emitting luminescent material lies in the wavelength range from 610 to 630 nm.

20 In a favorable embodiment of the lighting system in accordance with the invention, a luminous flux of the opto-electronic element is, during operation, at least 5 lm. The invented lighting system enables a continuous, uniform illumination with a high intensity to be obtained. It has been found that opto-electronic elements having a luminous flux of 5 lm or more can only be applied in an efficacious manner if the lighting system comprises heat-
25 dissipating means. Only lighting systems provided with opto-electronic elements having such a high luminous flux can replace customary incandescent lamps. A particular aspect of the invention resides in that the heat-dissipating means dissipate the heat generated during operation of the lighting system to a lamp cap of the lighting system and/or the mains supply connected thereto.

30 These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

In the drawings:

Fig. 1 shows, partly in cross-section and partly in side-elevation, a first embodiment of the lighting system in accordance with the invention;

Fig. 2A is a cross-sectional view of an embodiment of the body in accordance with the invention;

5 Fig. 2B is a cross-sectional view of an alternative embodiment of the body in accordance with the invention, and

Fig. 2C is a cross-sectional view of a further alternative embodiment of the body in accordance with the invention.

10 The Figures are purely diagrammatic and not drawn to scale. Particularly for clarity, some dimensions are exaggerated strongly. In the Figures, like reference numerals refer to like parts whenever possible.

Fig. 1 shows an embodiment of the lighting system in accordance with the invention, partly in cross-section and partly in side-elevation. Said lighting system comprises, in this example, a body 1 in the form of a spirally wound wire. The lighting system further comprises an envelope 5 which is light-transmitting and a lamp cap 7 which is known per se. In accordance with the invention, the lighting system includes at least one opto-electronic element 2, 2'. In the example of Fig. 1, two opto-electronic elements 2, 2' are shown. Such opto-electronic elements are composed of a body for generating and emitting light in a predetermined wavelength range, during operation, and they are generally provided with a light-transmitting envelope, for example in the form of a lens. Suitable opto-electronic elements 2, 2' are so-called electroluminescent elements, for example light-emitting diodes (LEDs), such as diodes emitting light of a specific color. Suitable LEDs include, inter alia,

15

20

- blue GaN LEDs (make Nichia): emission maximum: 470 nm, FWHM = 20 nm;
- blue-green GaN LEDs (make Nichia): emission maximum: 520 nm, FWHM = 40 nm;
- 25 - yellow GaP LEDs (make Hewlett Packard): emission maximum: 590 nm, FWHM = 20 nm.

The body 1 is provided with conversion means 3. Said conversion means 3 are excited by light originating from the opto-electronic element 2, 2'. A part of this light is converted by the conversion means 3 to (visible) light in the second wavelength range. In the example of Fig. 1, the body 1 is not entirely provided with conversion means 3. The parts of the body 1 which do not have to emit light are not provided with the conversion means 3.

30

The conversion means 3 preferably comprise a luminescent material. Suitable luminescent materials for converting blue light to green light are:

(Sr,Ca)₂SiO₄: Eu²⁺, Ba₂SiO₄: Eu²⁺, SrGa₂S₄, ZnS: Cu⁺, ZnS: Au⁺, ZnS: Al³⁺, (Zn,Cd)S: Ag⁺ and CaS: Ce³⁺. Suitable luminescent materials for converting blue light or green light to red light are: CaS: Eu,Mn; CaS: Eu; SrS: Eu; (Zn,Cd)S: Ag; SrO: Eu; Sr₃B₂O₆: Eu; Sr₂Mg(BO₃)₂; CaS: Eu,Mn; CaS: Eu or SrS: Eu. Said materials have a relatively high quantum efficiency and light absorption. These materials further have a relatively very high lumen equivalent upon converting light from the first wavelength range to light of the second wavelength range.

The (visible) light-transmitting envelope 5 of the lighting system is provided with a coating which (partly) reflects light of the first wavelength range. As a result thereof, light of the first wavelength range which originates from the opto-electronic element 2, 2', and which is not directly, or not completely, converted to light in the second wavelength range by the conversion means 3 is reflected by the reflective coating 6 applied to the envelope 5 and still converted by the conversion means 3 to light in the second wavelength range. Light originating from the conversion means 3 is passed by the envelope 54 coated with the reflective coating 6.

Preferably, the coating 6 comprises a multilayer reflective coating. Such coating layers can be readily applied by means of coating techniques which are known per se (vapor deposition, sputtering, chemical vapor deposition, dip coating). A suitable coating layer comprises a coating composed of a stack of relatively thin layers of a material having alternately a high and a low refractive index, for example Nb₂O₅, Ta₂O₅ or Si₃N₄ being used as the material having a high refractive index, and, for example SiO₂ or MgF₂ being used as the material having a low refractive index. By a suitable choice of the respective layer thicknesses, the desired reflection spectrum is obtained.

Preferably, the coating 6 reflects blue light. If the opto-electronic element 2, 2' emits blue light, this light, provided it is not converted by the conversion means 3, is reflected by the coating 6, so that such light cannot leave the envelope 5. Light originating from the conversion means 3 is passed by the envelope 5 coated with the reflective layer. Consequently, the lighting system in accordance with the invention has a body which, in operation, emits visible light.

Preferably, the coating 6 is provided at a surface of the envelope 5 which is directed towards the body 1. By virtue thereof, damage to the coating during operation of the lighting system is precluded.

In the example of Fig. 1, the lighting system is provided with an adjusting ring 8 for changing the luminous flux of the opto-electronic element. This adjusting ring 8 enables the lighting system to be dimmed, as it were. The lighting system may also be provided with a

second adjusting ring (not shown in Fig. 1) by means of which the luminous flux of the opto-electronic elements 2, 2' can be changed with respect to each other. The lamp may also be provided with a third adjusting ring (not shown in Fig. 1) by means of which the color and/or the color temperature of the light emitted by the lighting system can be changed. Said
5 adjusting rings may also be integrated so as to form a single adjusting ring having various adjustment positions. The lighting system may additionally be provided with extra opto-electronic elements, for example of a different color, so that the desired color rendering index of the lighting system is obtained.

The lighting system in the embodiment shown in Fig. 1 is a look-alike of a
10 carbon filament lamp because the body 1 comprises a spirally wound wire which, in operation, emits visible light, and because the lighting system is provided with a light-transmitting envelope. The conversion means on the spiral convert blue light originating from the opto-electronic elements to visible light in a higher wavelength range than that of the blue light. In comparison with the known lighting system, the lighting system in accordance with the
15 invention has the advantage that a relatively high luminous efficacy (≥ 20 lm/W) of the system and a very long service life ($\geq 75,000$ hours) are achieved.

Figs. 2A, 2B and 2C diagrammatically show cross-sectional views of various embodiments of the body in accordance with the invention. Fig. 2A shows a body in the form of a cross-shaped element 21 provided with conversion means 23. Fig. 2B shows a body in the
20 form of a star-shaped element 31 provided with conversion means 33 and supporting means 37. In general, the supporting means 37 are not provided with a coating. Fig. 2C shows a body in the form of a decorative element 41, 41' provided with conversion means 43, 43'. Fig. 2C does not show supporting means which are used to secure the decorative element 41, 41' to the lamp cap.

25 It will be clear that within the scope of the invention, many variations are possible to those skilled in the art. For example, the shapes of the bodies are not limited to the shapes shown in Figs. 1, 2A, 2B and 2C. Many alternative embodiments are possible, such as (three-dimensional) bodies in the form of so-called devotional elements, such as statues in the form of (saint's) figures. Other alternative embodiments include models of architectural origin
30 or pictures or other (two-dimensional) images which are provided with luminescent materials (by the user) at suitable locations (for example at the edge). The body may alternatively (partly) allow passage of (visible) light, so that the opto-electronic elements are hidden underneath the body and constitute a part of the lighting system which is invisible to the observer. The application of the conversion means is not limited to one type thereof.

Alternatively, a combination of conversion means or luminescent materials may be used. Furthermore, also various parts of the body may be coated with different conversion means, so that these parts may have a different color. By suitable combinations of opto-electronic elements and conversion means, various light and color effects can be achieved, which can be adjusted (via an adjusting ring) by the user. For example, by a suitably chosen combination of blue and green opto-electronic elements with a phosphor which is sensitive to both blue and green light and which emits red light, a color effect can be obtained by changing the balance between blue and green light. In this case, it is desirable for the reflective coating to partly reflect both blue and green light. The envelope of the lighting system provided with the reflective coating may be omitted, if so desired. In this case, the lighting system comprises a combination of at least one opto-electronic element and (a body provided with) conversion means. It is also possible to omit the reflective layer. In this case, the body is irradiated only from below and no longer emits light homogeneously.

The scope of protection of the invention is not limited to the above examples.

- 15 The invention is embodied in each new characteristic and each combination of characteristics. Reference numerals in the claims do not limit the scope of protection thereof. The use of the term "comprising" does not exclude the presence of elements other than those mentioned in the claims. The use of the term "a" or "an" before an element does not exclude the presence of a plurality of such elements.

CLAIMS:

1. A lighting system comprising a body (1) which, in operation, emits visible light and comprising an envelope (5) which transmits light, characterized
in that the lighting system comprises at least one opto-electronic element (2, 2') which, in operation, emits light in a first wavelength range,
5 in that the body (1) is provided with conversion means (3) for converting light of the first wavelength range to light of a second wavelength range, and
in that the envelope (5) is provided with a coating (6) which at least partly reflects light of the first wavelength range.

10 2. A lighting system as claimed in claim 1, characterized in that the conversion means (3) comprise a luminescent material.

3. A lighting system as claimed in claim 1 or 2, characterized in that the conversion means (3) can be excited by light originating from the wavelength range of 400 to
15 500 nm.

4. An opto-electronic element as claimed in claim 1 or 2, characterized in that the opto-electronic element (2, 2') comprises a light-emitting diode.

20 5. A lighting system as claimed in claim 1 or 2, characterized in that the coating (6) comprises a multilayer reflective coating.

6. A lighting system as claimed in claim 1 or 2, characterized in that the coating (6) reflects blue light.

25 7. A lighting system as claimed in claim 1 or 2, characterized in that the coating (6) is provided at a surface of the envelope (5) which is directed towards the body (1).

8. A lighting system as claimed in claim 1 or 2, characterized in that the body (1) comprises a spirally wound wire.

9. A lighting system as claimed in claim 1 or 2, characterized in that the body
5 comprises a cross-shaped element (21), a star-shaped element (31) or a decorative element (41, 41').

10. A lighting system as claimed in claim 1 or 2, characterized in that, in operation, a luminous flux of the opto-electronic element (2, 2') is at least 5 lm.

1/2

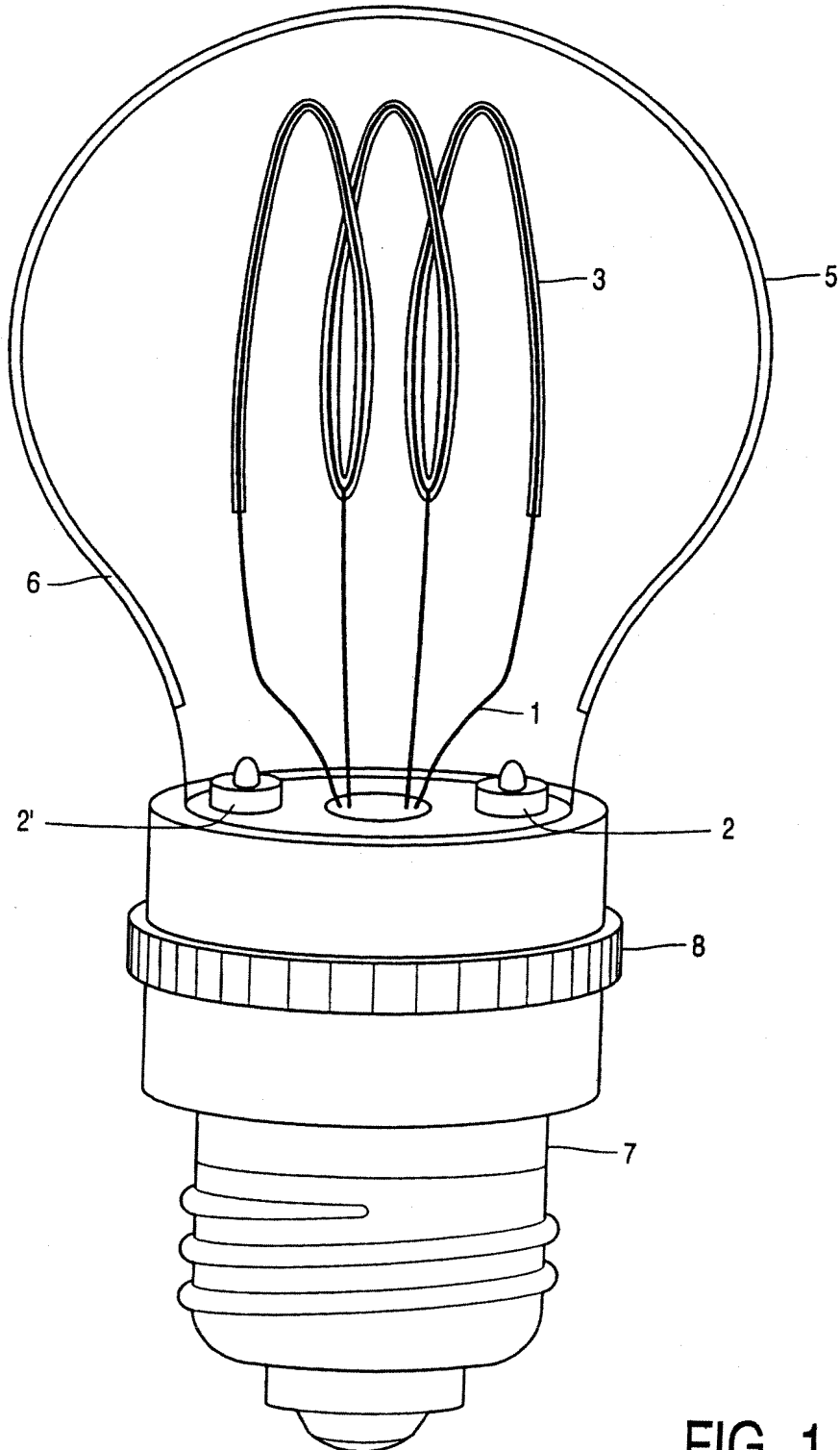


FIG. 1

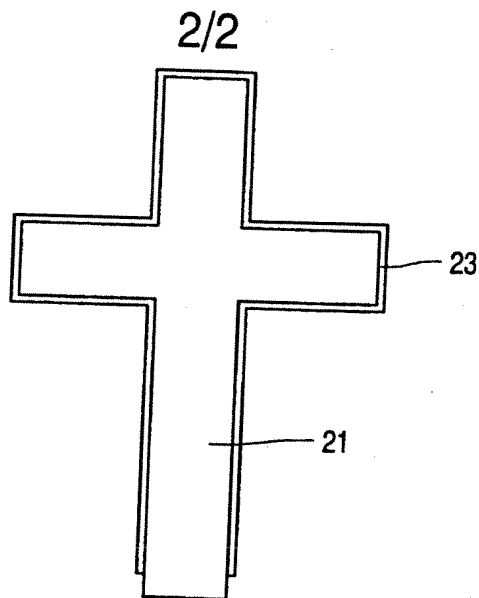


FIG. 2A

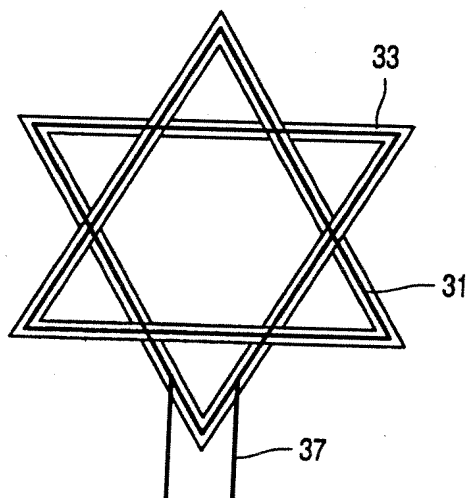


FIG. 2B

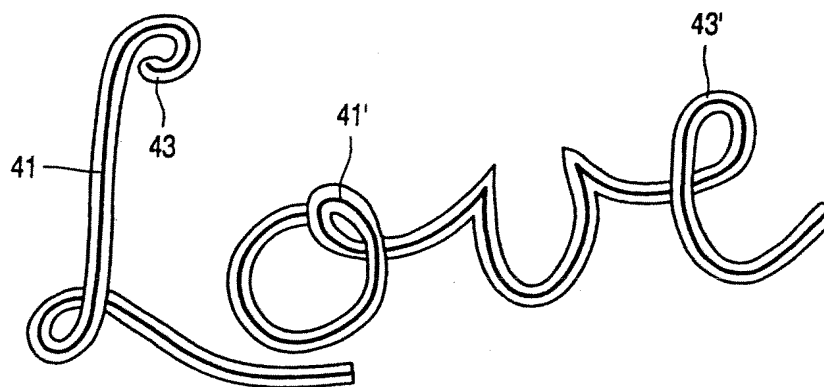


FIG. 2C

INTERNATIONAL SEARCH REPORT

Internal Application No

PCT/EP 00/03074

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01L33/00 H01L25/075 F21K7/00 //F21W121:00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F21K H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EP0-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 813 753 A (RONDA CORNELIS ET AL) 29 September 1998 (1998-09-29) column 3, line 17 - line 43 column 4, line 65 -column 5, line 16 column 6, line 66 -column 7, line 1; figures ----	1-6
X	US 3 593 055 A (GEUSIC JOSEPH E ET AL) 13 July 1971 (1971-07-13) column 4, line 46 - line 63; figures ----	1,2,4,7
X	US 3 932 881 A (MITA YOH ET AL) 13 January 1976 (1976-01-13) column 3, line 19 -column 5, line 14; figures ----- -/--	1,2,4,7

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

7 July 2000

Date of mailing of the international search report

17/07/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Brévier, F

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/03074

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
------------	--	-----------------------

A	<p>EP 0 855 751 A (IBM) 29 July 1998 (1998-07-29) column 5, line 25 - line 49; figures 5, 6A, 6B</p> <p>-----</p>	3
---	--	---

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/EP 00/03074

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5813753 A	29-09-1998	EP 0922305 A WO 9854929 A	16-06-1999 03-12-1998
US 3593055 A	13-07-1971	BE 748882 A DE 2018318 A FR 2043402 A GB 1284659 A	16-09-1970 12-11-1970 12-02-1971 09-08-1972
US 3932881 A	13-01-1976	JP 49046382 A JP 49075082 A	02-05-1974 19-07-1974
EP 0855751 A	29-07-1998	US 5898185 A US 5895932 A JP 10214992 A	27-04-1999 20-04-1999 11-08-1998